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Environmental Technology Verification Program
ETV

Greenhouse Gas Monitoring Technologies

The U.S. EPA Environmental Technology Verification (ETV) Program's Advanced Monitoring Systems (AMS) Center, operated by Battelle under a cooperative agreement with EPA, has verified[1] 11 technologies that can be used to monitor greenhouse gas (GHG) precursors and GHGs such as carbon dioxide (CO_2), chlorofluorocarbons, methane, various nitrogen oxides (NOx), ozone (O_3), and total hydrocarbons (THC). In 2009, the AMS Center also plans to verify CO_2 monitors at carbon sequestration sites.

GHG Pollution at a Glance

EPA estimates that, in 2002, the United States emitted almost 6.4 billion tons of CO_2 and nearly 22 million tons of NOx. There is support for the position that human activities generate GHGs, thus increasing their concentration in the atmosphere. If GHGs continue to increase, climate models predict that the average temperature at the Earth's surface could increase from 3.2 to 7.2 ºF above 1990 levels by the end of this century (EPA, 2009). Increasing global temperatures will cause sea level rise and changes in global precipitation patterns.

Verification Testing Description

Between 1999-2008 the AMS Center verified 11 GHG monitoring technologies. These technologies were verified for measurement of the different GHGs listed. Other gaseous pollutants were also measured. **Table 1** provides a description of the technologies and the gases measured during testing. Range, detection limits, percent recovery, relative accuracy, bias, precision, and other factors were verified. Selected performance data are available in **Table 2**, and details are available in the verification reports for each technology at http://www.epa.gov/nrmrl/std/etv/vt-ams.html, under the Air category. Monitoring data were compared to results obtained from air samples analyzed using EPA Method 3A for CO_2, EPA Method 7E for NOx, EPA methods from 40 CFR Part 86 for THC, and direct instrument comparison for O_3 (EPA, 1997, 2004).

Table 1. Portable GHG Emission Monitoring Technologies and Descriptions

Vendor/Technology (Verification Year)	Technology Description
JSC OPTEC Ltd., 3.02 P-A, Chemiluminescent Ozone Analyzer (2008)	Rack-mounted technology combines solid phase chemiluminescence with menu-driven software including diagnostic functions. Technology detects ambient O_3 through a chemical reaction with a solid-phase reactant of proprietary composition.
Testo, Inc., Model 350 Portable Multi-Gas Emission Analyzer (2003)	Portable technology uses electrochemical sensors to measure oxygen (O_2), carbon monoxide (CO), NOx (NO and NO_2), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), and THC from combustion sources. Technology was verified for CO, NO, NO_2, O_2, SO_2, measurements.
Clean Air Technologies International, Inc., REMOTE On-Board Emissions Monitor (2003)	Technology uses infrared and electrochemical techniques to measure CO, CO_2, THC, and NOx. Technology is capable of measuring exhaust emissions from late-model (1996-present) passenger vehicles with on-board diagnostics ports.
Bacharach, Inc., Model ECA 450 (2000)	Analyzer uses electrochemical sensors. Can be fitted with up to seven gas sensors to measure O_2, CO (two ranges), NO, NO_2, SO_2, and THC. Only NO and NO_2 measurements were verified in the test.
COSA Instruments Corp., 7000 Vario Plus (2000)	Analyzer uses electrochemical sensors. Measures oxygen, carbon monoxide, oxides of nitrogen (NO and NO_2), and sulfur dioxide emissions from combustion sources. Calculates carbon dioxide concentrations, combustion efficiency, excess air, and flue gas losses. Only NO and NO_2 measurements were verified in the test.
Land Combustion, LANCOM Series II (2000)	Analyzer uses electrochemical sensors. Can be fitted with up to seven gas sensors to measure O_2, CO (two ranges), NOx (NO and NO_2), SO_2, and THC. Only NO and NO_2 measurements were verified in the test.
ECOM America, Ltd., A-Plus (1999)	Analyzer uses electrochemical sensors. Measures O_2, CO, NOx (NO and NO_2), and SO_2 emissions. Only NO and NO_2 measurements were verified in the test.
Enerac/Energy Efficiency Systems, Inc., Enerac 3000E (1999)	Analyzer combines sensor technology for NOx (NO and NO_2) measurement with automatic quality control features. Can be operated remotely through a two-way modem connection. Performance parameters can be remotely checked by the factory.
Horiba Instruments, Inc., Horiba PG-250 (1999)	Analyzer employs non-dispersive infrared detection for SO_2, CO, and CO_2; chemiluminescence detection of NOx; and electrochemical cell for O_2. Only NO and NO_2 measurements were verified in the test.
Testo, Inc., Model 350 (1999)	Analyzer uses electrochemical sensors to measure O_2, CO, NOx (NO and NO_2), SO_2, H_2S, and THC. Also captures data on pressure, temperature, and flow. Only NO and NO_2 measurements were verified in the test.
TSI, Inc., Combucheck Single Gas Monitor (1999)	Hand-held single gas monitor that uses interchangeable electrochemical sensors. Can measure O_2, CO, NOx (NO and NO_2), and SO_2. Only NO and NO_2 measurements were verified in the test.

[1] The ETV Program operates largely as a public-private partnership through competitive cooperative agreements with non-profit research institutes. The program provides objective quality-assured data on the performance of commercial-ready technologies. Verification does not imply product approval or effectiveness. ETV does not endorse the purchase or sale of any products and services mentioned in this document.

Selected Outcomes of Verified GHG Monitoring Technologies

In 2009, the U.S. EPA has undertaken a number of initiatives intended to monitor and reduce GHG emissions. In April, EPA announced proposed rulemaking for mandatory reporting of GHG emissions from all sectors of the economy (EPA, 2009b). Additionally, EPA has developed several Climate Leaders Offset Project Methodologies that use a standardized approach to determine GHG reduction projects, select and set baseline emissions, identify monitoring options, and quantify reductions (EPA, 2009c). A major component of these, and other new GHG initiatives, is monitoring technologies.

Real-time monitoring technologies like those verified by AMS can be used by EPA and others to help determine when GHG emissions occur, establish baseline emissions, quantify reductions, and determine compliance.

Table 2. Selected Performance of GHG Monitoring Technologies

JSC OPTEC Ltd., 3.02 P-A, Chemiluminescent Ozone Analyzer	O_3	51–260 ppb	< 1 ppb	%R: 83.4-110
Testo, Inc., Model 350 Portable Multi-Gas Emission Analyzer (low and high concentration sensors)	CO NO NO_2 O_2 SO_2	0-5000 ppm 0-2500 ppm 0-2500 ppm 0-25% 0-2000 ppm	0.25-1.22 ppm 0.25-1.66 ppm 0.26-0.41 ppm ND[b] 1.24 ppm	RA:1.52-16.1% RA:6.95-10.4% RA:21.8-25.6% RA:0.30-0.82% RA:4.70%
Clean Air Technologies International, Inc., REMOTE On-Board Emissions Monitor	CO CO_2 THC NOx	0-13 g/mile 300-620 g/mile 0-1 g/mile 0-1.4 g/mile	ND[b]	A: 2.54±1.12 A: 3.17±1.40 A: 6.04±2.66 A: 4.03±1.78
Bacharach, Inc., Model ECA 450 (low and high concentration sensors)	NO NO_2	0-1000 ppm 0-450 ppm	8-11 ppm 3-4 ppm	RA:1-10.5% RA:1-19.5%
COSA Instruments Corp., 7000 Vario Plus	NO NO_2	0-2000 ppm 0-512 ppm	3-4 ppm 2-4 ppm	RA for NOx: 2.8-10.7%
Land Combustion, LANCOM Series II	NO NO_2	0-2000 ppm 0-512 ppm	2.5 ppm 1.5-2.3 ppm	RA for NOx: 1.8-17.5%
ECOM America, Ltd., A-Plus	NO NO_2	0-3500 ppm 0-450 ppm	4 ppm 1.2 ppm	RA for NOx: 1.5-12.1%
Enerac/Energy Efficiency Systems, Inc., Enerac 3000E	NO NO_2	0-3000 ppm 0-400 ppm	1.2-8.3 ppm 6 ppm	RA for NOx: 11-20%
Horiba Instruments, Inc., Horiba PG-250	NO NO_2	0-2500 ppm 0-500 ppm	6-7 ppm 9-16 ppm	A:2-8.5% A:35-50%
Testo, Inc., Model 350	NO NO_2	0-3000 ppm 0-500 ppm	6 ppm 1.9 ppm	RA for NOx: 5.8-11.4%
TSI, Inc., Combucheck Single Gas Monitor	NO NO_2	0-2000 ppm 0-100 ppm	20-25 ppm 1.5-3 ppm	8.6-40.4 ppm ND[b]

[a] %R = Percent recovery; RA = Relative accuracy; A = Accuracy (bias and precision)
[b] ND = Not determined
ppb = parts per billion
ppm= parts per million
g/mile = grams per mile

References

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ETV Advanced Monitoring Systems Center

ETV Advanced Monitoring Systems Center (AMS) verifies the performance of technologies that detect contaminants and natural species in air, water, and soil. AMS is operated by Battelle, a non-profit technology research and development organization, under a cooperative agreement with EPA. To date, AMS has completed verification tests of over 125 technologies, including continuous emission monitors for mercury, dioxin, and ammonia; ambient monitors for fine particulate, ammonia, hydrogen sulfide and ozone; test kits for arsenic, cyanide, atrazine, and other water contaminants; and multi-parameter water probes. Nearly 20 additional technologies are currently in the verification testing process. For further information, please contact:

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